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Discussions

Interactive comment on "Modelling drivers of mangrove propagule dispersal and restoration of abandoned shrimp farms" *by* D. Di Nitto et al.

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Anonymous Referee #2 Received and published: 11 April 2013 Comments: Di Nitto et al (Modelling drivers of mangrove propagule dispersal and restoration of abandoned shrimp farms) Biogeosciences Discuss., 10, 1267–1312, 2013

1. This study is a welcome effort in the pioneering field of restoration ecology of mangroves.

We thank the referee for this positive comment on our efforts in modelling propagule dispersal in view of restoration of abandoned shrimp farms. As mentioned in the

manuscript, seed ecology is a well-developed field but the actual understanding of propagule dispersal processes has not been fully advancing in recent years. In this manuscript we explored some of the possibilities of a combined bio-physical modelling set-up to simulate mangrove propagule dispersal in a pioneering study that has provided new insights in propagule dispersal processes. It was timely to explore possible propagule behaviour based on a substantial amount of field data against the backdrop of often repeated but little tested views on mangrove dispersal ecology.

2. Most abandoned ponds in the Philippines are seaward in location (cause of abandonment is dike breaching), and therefore the need for mangrove regrowth is urgent in light of sea level rise and increasing storm intensity and frequency, in addition to the 20 or so typhoons that come each year.

The necessity of mangrove regrowth in abandoned ponds on the seaward side is indeed urgent. Sea level rise and increasing storm intensity and frequency are problems of climate change that we are facing worldwide. In Sri Lanka, preliminary post-tsunami surveys of Sri Lankan mangrove sites with different degrees of degradation indicated that human activity exacerbated the damage inflicted on the coastal zone by the tsunami (Dahdouh-Guebas et al., 2005). In other words, mangroves were shown to function as protective buffers to shield coastal villages from destruction. Mangrove sites with no cryptic ecological degradation, or those well protected by distance inland and by Rhizophora spp. fringes, all experienced a low destructive impact from the tsunami. It was also shown that three factors could undermine this function as a protective buffer, being complete clearance, insufficient regrowth after clearing and infusion of adult mangroves with excess of non-mangrove components. Although this study was conducted under post-tsunami conditions, the same conclusions are relevant to a wide variety of extreme weather events and natural catastrophes, as the typhoons that frequently afflict the coastlines of the Philippines (Walters, 2003; 2004). We have added a comment to the text to accommodate this aspect, with reference to the following papers.

Dahdouh-Guebas, F., L.P. Jayatissa, D. Di Nitto, J.O. Bosire, D. Lo Seen & N. Koedam, 2005. How effective were mangroves as a defence against the recent tsunami ? Current Biology

Walters, B.B. (2003). People and mangroves in the Philippines: fifty years of coastal environmental change. Environ. Conserv. 30, 293–303.

Walters, B.B. (2004). Local management of mangrove forests in the Philippines: successful conservation or efficient resource exploitation? Hum. Ecol. 32, 177–195.

3. Natural ecological succession (Natural Regeneration or NR) will take 15-20 years for mangroves to fully recover (Primavera et al, 2012a), whereas Assisted Natural Regeneration (ANR) using the harvest and transplantation of excess wildings has allowed the return of a 9-ha pond into mangroves in only 4 years, with some of the wildings flowering in just 3 years after transplantation (Primavera et al, 2012b).

In our manuscript we estimated the time it takes for an abandoned shrimp farm area to naturally regenerate on the basis of case studies reported from southern Thailand and the Philippines. These particular studies have shown the potential for converting abandoned shrimp ponds areas back to mangroves within a period of about 5 to 10 years, provided that there is sufficient natural recruitment of viable propagules and that hydrological conditions are restored (Lewis III et al. 2002). We will expand our references with the findings of Primavera et al, 2012a and 2012b as we agree that all vital and recent information on this topic needs to be included. We will also include reference to Bosire et al. (2008), which further expands on the critical steps towards of successful Ecological Mangrove Rehabilitation (EMR) of Lewis et al. (2006), focusing on floristic succession, faunistic recruitment, environmental factors and so forth.

In our study area (Pambala Chilaw Lagoon Complex) natural mangrove regeneration has occurred within some abandoned aquaculture ponds in the Pambala-Chilaw Lagoon Complex, yet most ponds remain uncolonised even after several years of abandonment (Quisthoudt 2007). We have made in situ observations that some degree

of natural regeneration has occurred within a few abandoned ponds in favour of Rhizophora spp. At present, the tidal flooding regime in these shrimp farm areas is however still blocked by the exsisting shrimp farm infrastructure. The main focus of our study was therefore not to investigate how we can apply Assisted Natural Regeneration (ANR) using the harvest and transplantation of excess wildings, but first of all to see which scenario of strategic breaching of the shrimp farm dikes could lead to the highest inflow of mangrove propagules of the various concerned species. We do not yet know whether or not natural recruitment would provide the quantity of successfully established seedlings, rate of stabilization or rate of growth of saplings required to meet the objectives and expectations of a mangrove restoration project in this study area. In any case, we suggest that monitoring of natural regeneration of mangrove vegetation in this area is worthwhile and would be beneficial in informing any future rehabilitation efforts in the Pambala Chilaw Lagoon. If seedlings have established in the rehabilitation area, but at lower densities or rates than hoped for, it would be suggested to proceed with an ANR. A comment to reflect this has been added to the text.

4. The use of wild recruits or wildings in ANR is based on mangrove seedling counts of up to 30/sq m in crowded pockets (Primavera et al, 2007). Such high counts are due to trapping mechanisms whether natural (dense pneumatophores, other root structures) or artificial (dikes of abandoned ponds) which retain the propagules otherwise washed away by tidal or river flow. It would be interesting to know the densities of wild recruits in the present study, in areas with roots present and bare soil (without roots/ other trapping mechanisms). Also, future studies could determine the no/ per cent mangrove seedlings that should remain untouched for the new generation – to guide projects that apply ANR and use wildings.

If the monitoring results of the restoration project would indicate that ANR is needed, mangrove seedling densities in different environmental settings (root complex, topography, soil, salinity, etc) would be available for our study area. Our research group has conducted research in the Pambala Chilaw Lagoon Complex and other mangrove areas in Sri Lanka for the past decennia. First of all, Verheyden, et al. (2002) used aerial photographs for monitoring mangrove vegetation dynamics at high resolution. For the purpose of these analyses ground-truthing occurred by recording species presence on a number of transects using the point-centered- quarter method or PCQM. In addition to this field data, Dahdouh-Guebas et al. (2010) performed ordination techniques to study the dynamics of a vegetation assemblage by using different vegetation layers (adult trees, young trees, and juvenile trees) per species as an input. Annual monitoring of the juveniles was done to check whether or not the forest was rejuvenating. In addition, the relationship between propagule predators and both vegetation structure and environmental factors (topography, water level, rainfall and season) was investigated by Dahdouh-Guebas et al. (2002). A comment to reflect this has been added to the text.

Dahdouh-Guebas, F., N. Koedam, B. Satyanarayana, S. Cannicci, 2010. Human hydrographical changes interact with propagule predation behaviour in Sri Lankan mangrove forests. Journal of Experimental Marine Biology and Ecology 399(2): 188-200.

Verheyden, A., F. Dahdouh-Guebas, K. Thomaes, W. De Genst, S. Hettiarachchi & N. Koedam, 2002. High resolution vegetation data for mangrove research as obtained from aerial photography. Environment, Development and Sustainability 4(2): 113-133.

Dahdouh-Guebas, F., J.G. Kairo, L.P. Jayatissa, S. Cannicci & N. Koedam, 2002. An ordination study to view vegetation structure dynamics in disturbed and undisturbed mangrove forests in Kenya and Sri Lanka. Plant Ecology 161(1): 123-135.

5. Many Southeast Asian countries focus on seafront planting in the mid- to lower intertidal (vs pond reversion in the upper intertidal) for reasons of convenience, presence of communities unable to relocate elsewhere, etc. What are the implications, if any, of the present results on seafront planting?

In the study area of the Pambala Chilaw Lagoon Complex, the lagoon structure and the microtidal regime give a different view on the mid-lower vs upper tidal mangrove

regions. Strong sea currents are lead through the lagoon entrance where after mangroves have the opportunity to thrive along the lagoon banks. Topographical differences here are very small. As research is done in close collaboration with a local NGO adjacent to the mangroves, mangrove planting is well organized and planting is not conducted along the seaside. A mangrove rehabilitation project by the Small Fishers Federation of Lanka led to the planting of about 50 000 mangrove seedlings in Pambala Lagoon (Anuradha Wickramasinghe and Daglas Thisera, SFFL, pers. comm., 1997), in an area inland, close to the shrimp farm areas. The reforestation plots are often visited in the field and estimated to cover about 2.4 ha.

6. References – it is important to include not only the latest references on a given topic but also the earliest, for better historical perspective. For example, mangrovepond conversion was already reported in peer-reviewed journals in the early 1990s (see Primavera 1991, 1993, etc.).

Additional Refs Primavera, J.H. 1991. Intensive prawn farming in the Philippines: Ecological, social and economic implications. Ambio 20: 28-33. Primavera, J.H. 1993. A critical review of shrimp pond culture in the Philippines. Rev. Fish. Sci. 1: 151-201

Primavera JH, RN Rollon, and MS Samson. 2012a. The Pressing Challenges of Mangrove Rehabilitation: Pond Reversion and Coastal Protection. Chapter 10 in Volume 10: Ecohydrology and restoration, (eds., L. Chicharo and M. Zalewski) in the Treatise on Estuarine and Coastal Science (Series eds., E. Wolanski, and D. McLusky), Elsevier, Amsterdam, pp. 217-244

Primavera JH, Savaris JD, Bajoyo B, Coching JD, Curnick DJ, Golbeque R, Guzman AT, Henderin JQ, Joven RV, Loma RA & Koldewey HJ. 2012b. Manual for community-based mangrove rehabilitation. London, UK: Zoological Society of London, viii + 240 p.

Full citation details of these additional references (and others metioned in our response to comments above) have now been included in the ‘References’ section and added to the revised text of the manuscript.

Interactive comment on Biogeosciences Discuss., 10, 1267, 2013.